Magnetostatic interaction and hysteresis loop shape of ordered permalloy bars arrays

V. Skidanov, A. Stempkovskij

I. Introduction

It was shown recently that thin film permalloy (80Ni-20Fe) rectangular bars with high aspect ratio and width w up to ~ 50 mcm are much more probably in quasi-saturated than in demagnetized state. Hysteresis loops of bars regular arrays have parallelogram-like shapes with distinct critical and saturating field parameters H_{cr} and H_s which are shown to be strictly definite functions of bar width w, thickness t and density of the bars array [1]. Since edges of each bar were found to be entirely demagnetized the role of magnetostatic interaction between bars in array with respect to longitudinal remagnetization process and hysteresis loop formation is of particular interest.

II. Purpose

Negligible spread of H_{cr} and H_s for bars in array gives convenient instrument for experimental investigation of bar-bar magnetostatic interaction. Measurement of bars stray field influence on array hysteresis loop shape is the purpose of present work.

III. Procedure and results

Ordered bars arrays were investigated by means of magnetooptical Kerr setup for a number of permalloy film thicknesses (25 – 150 nm) and bar widths (1 – 20 mcm) with respect to variation of gap g between adjacent bars in column.

Each bars array is made up by parallel columns located far enough from each other so that column-column interaction is neglected as shown in Fig.1a. Gap value g variation was accomplished at constant w and t. Few bars near columns edges in matrix have critical field values exceeding that for inner bars so hysteresis loop shape is defined by regular internal part of each array.

Fig. 2 shows examples of hysteresis loop for 4 mcm-width arrays. It is clearly shown that bar critical field H_{cr} is very sensitive to stray field values of adjacent bars. Stray field influence falls during remagnetization process so that H_s looks independent on film thickness and bar density in array. Saturation is completed at the middle region of each bar where stray fields are negligible. Complex arrays made up by two identical simple subarrays inserted to each other with bar half length shift (Fig. 1b) exhibit the same rectangular loop parameters as every of its both component subarrays (Fig. 2, loop C) except double signal due to double array density.

V. Skidanov and A. Stempkovskij are with Institute for Design Problems in Microelectronics RAS, Moscow, Russia. E-mail: skidanov@zelnet.ru

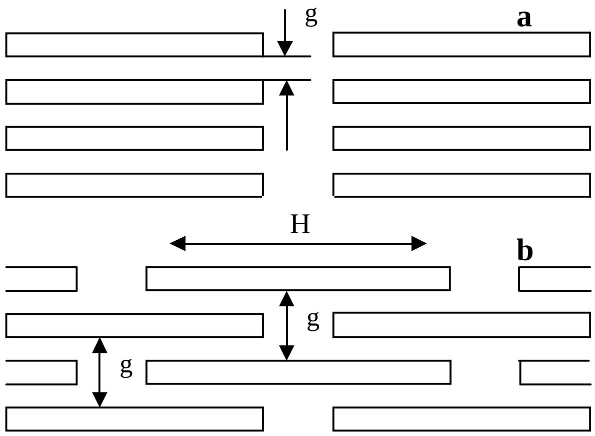

Fig. 1. Ordered permalloy bars arrays:
a – simple matrix structure, b – two inserted and shifted subarrays.

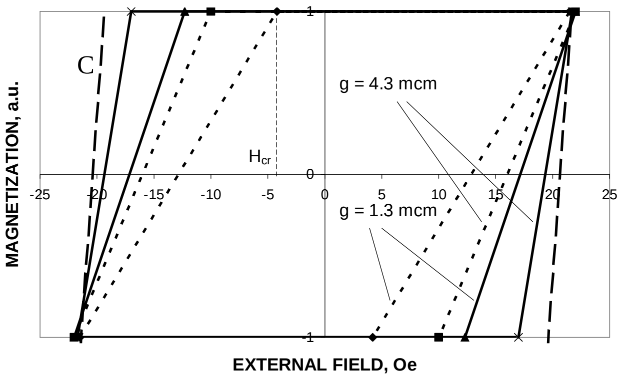

Fig. 2. Hysteresis loops for permalloy bar arrays with two gaps g, bar width w = 3.7 mcm, solid lines – t = 50 nm, dotted lines – t = 150 nm, C – simple and complex arrays (w = 3,7 mcm, t = 50 nm, g = 6,3 mcm).

Procedure described can be used for monodomain bar stray field in-plane component distribution determination (with up to tens nanometers space resolution) as a difference between H_{cr} (g) for a number of bars arrays and a critical field H_{cr} for remote identical bar. No other way is known up to now.

It should be noticed no similar dependences were revealed for 90Ni-10Fe permalloy film bars arrays for which H_{cr} and H_s were found to be identical to continuous film hysteresis loop parameters.

References

[1] V. Skidanov, “Peculiarities of permalloy thin film microcore hysteretic magnetization process in high space resolution fluxgate device”, Journal of Magnetism and Magnetic Materials, 320 (14), e296 - e299 (2008)